

Mathematical vol. 1
A
LETTER
OF
ADVICE
TO ALL

The Worthy and Ingenuous Merchants of the City
of *London*, and elsewhere in *England*, *Scotland*,
and *Ireland*; And also to all the Worthy and
Ingenuous Merchants of *France*, and of *Holland*
and the *United-Provinces*, and of *Germany*, *Spain*,
Portugal, *Denmark*, and *Sweden*, and elsewhere in
EUROPE;

AND

To all Ingenuous and Ingenious Artists in *Astronomy*,
Geography, and *Navigation*;

SHEWING

An exact, easie and speedy Way to know the *LONGITUDE*
of all Places in the World, where the *European* Merchants
have their *Agents* to make Observations;

AND ALSO

How the *LONGITUDE* of Places may be better known
upon Ship-board.

Written by *Digby Bull*, M. A. and late Rector
of *Sheldon* in *Warwick-Shire*.

L O N D O N:

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Worthy and Ingenious Gentlemen and Citizens,

IT is a Matter of great Use and Benefit to you and to all Persons that trade beyond the Seas, or are employed upon the Seas, to know exactly the Longitude of all the known Places beyond the Seas, and how many Degrees they are distant from us in Longitude, either towards the East or West. And as I am informed, the *English*, the *Dutch*, and the *French* have proffer'd Fifty Thousand Crowns each of them, to the Man that should shew them a way how the Longitude of Places might be as readily discovered as the Latitude of them. And towards the effecting of this, I do here undertake to shew you a ready Way how the Longitude of all Places in the World, where you have your Agents to make true observations, may be exactly, easily and speedily known: And also how the Longitude of Places, upon Ship-board may be more exactly known than hitherto they have been, so far as I see in this matter.

The way to find out the Longitude of Places has been by Eclipses; But the Eclipses of the Sun are very different and various, as Persons are distant either in Longitude or Latitude, by reason that the Moon is nigh the Earth in comparison of the great distance of the Sun from it: And therefore they are of little or no use in this matter. And the Eclipses of the 4 Secondary Planets about *Jupiter* cannot be observed without Telescopes, and are not yet truly calculated, and therefore are in a manner altogether useless in this respect. But the total Eclipses of the Moon have been very serviceable, and have given great Assistance in the finding out of the Longitude of Places. But these rarely happen, and can be observ'd but upon one side of the Earth at a time, and are often made useless by the interposition of Clouds. And the partial Eclipses of the Moon cannot be so exactly observ'd to a Minute or two of time, as is requisite in this Business. But I shall here shew another way of finding the Longitude of Places, which will be more exact than the total Eclipses of the Moon, and whereby above an Hundred Trials and Observations

vations may be made for One that can be made by a Total Eclipse of the Moon. And this Way is by a careful observing of the motion of the Moon by any of the fixed Stars of the first Magnitude that lie between the two tropical Circles of *Cancer* and *Capricorn*; but the Stars of the first magnitude near the Tropicks of *Cancer* or *Capricorn* seem the most convenient for this Purpose, and have some Advantage by the Moon's near approach to them in her greatest Latitude from the *Æquator*.

And for the more accurate observing of the motion of the Moon, to or from a fixed Star; first, it is necessary that the Meridians of the Places where the Observations are to be made, should be exactly taken: for if the Meridian that is observ'd be but one Minute in time awry, there will be an Error of a quarter of a Degree in Longitude, of the Place whose Longitude is to be taken. And there will be the same Error in observations that are made by total Eclipses of the Moon, if there be one Minute mistaken in the true time of the Night when an Eclipse happeneth. Therefore for the observing when any Star, or one side and edge of the Moon are exactly upon the Meridian of a Place, a long piece of Timber, with a strait side, may be set and fixed upright by a Plummer, with the strait side toward the *East*, for a Meridian Guide. And it will be convenient that the piece of Timber be set up so high, or else that the Ground behind it be sunk so low, that the *Radii* of the Moon and Stars may be taken at 20 Yards distance from the upper end of it, by which the Moon and Stars pass; and that the Sight for observation be set at that distance from it. A smooth and upright side of an House or other Building toward the *East*, that is high enough, will do very well for a Meridian Guide. And if the Moon and Star be of the same Latitude, or differ but little, then a smooth and upright Chimney upon an House will make a very good Meridian Guide to shew when a Star and the Edge of the Moon are exactly at the Meridian of any Place. An upright Guide will be the soonest made, and will serve very well in our Latitude to shew when the Moon or a Star is exactly upon the Meridian. But an upright Guide will not serve in the *Torrid Zone*, and under the *Æquator*; but there they must lay a strait Piece of Timber exactly North and South upon two upright Pieces of Timber, or upon two Pillars or high Houses or Buildings, or put it out from one of them for a Meridian Guide.

And

And to make exact observations, a Long Pendulum Clock, that pointeth at Hours, Minutes and Seconds, must be provided, which goeth well and is well adjusted. And I have invented a new way of Long Pendulum Clocks, which when they are well made, I hope will be useful for this Purpose, and keep time more exactly than the Clocks now in use; but many of these are good, and go well. And by a large Quadrant, fixed to a Stand, with liberty to be moved, the heighth of the Sun and the Hour of the Day may be taken, and the Clock set by it. And by the help of the Clock when it is at 12 a-Clock, the Sight may be placed to make observations by the East-side of the Meridian Guide, agreeing exactly with the Center of the Sun at 12 a-Clock. And it will be necessary to examine the Sight several times by the Quadrant and Clock in the Morning and in the Evening, whether it be exactly fixed or not; and to rectifie it, if it be awry. If this be often tried by a large Quadrant and a good Clock, the Meridian Guide and the Sight thereof may be well set to a quarter of a Minute, and then the Error will be very small, if any. Red Glass, or something else, may be used to weaken the Beams of the Sun when it is observed, and the Clock should be just one Minute past 12 when the East side and edge of the Sun, passeth behind the Meridian Guide. And, if it be thought convenient, a little Prospective Glass may be used in observing the Moon and Stars: And the Sight may be so contrived, that a Man (for his greater ease) may sit down while he observeth them.

It will be convenient that all Observers in all Parts of the World, should make this a constant Rule; viz. To make their Observations by the East side and edge of the Moon, when the Moon is at the Full and after the Full: But to make them by the West edge of the Moon, before the Moon is at the Full; because the East side and edge then is not so visible and fit for this purpose. And if the observation be made but an hour or two before the Full, it may be expressed by which side and edge of the Moon it was made. For if the side and edge of the Moon be mistaken, there will be a great Error in the Longitude of the Place. And to take the moment of time accurately, when a fixed Star, or the edge of the Moon passeth by the Meridian, it will be convenient that one Man should observe the Moon and Star; and that another should observe the Clock: And that he that observeth the Moon and Star should give notice

to him that observeth the Clock, when the body of the Star is just covered with the Meridian Guide, by some loud voice. And then he that observeth the Clock, having his eye upon the Index that pointeth at Seconds, may observe first, what Second it is, and then what Minute, and then what Hour. And then he will see how many Minutes and Seconds past any Hour the Star passed by the Meridian, and may carefully set them down, with the day of the Month. The Index of the Seconds must be first observed, because it moveth the fastest, and will be gone out of his place, if the other Indexes be first minded. The Clock must be placed in some convenient Room of an House near the Observer of the Moon and Star, that the observer of the Clock may easily hear his Voice. And the Observer of the Moon and Star may give notice to the other a Minute or two before the Star cometh to the Meridian, that he may be ready to observe the time exactly. And when the Moon cometh to the Meridian (which I suppose here to follow the Star) he may observe when the last side and edge of the Moon passeth out of sight and is just covered with the Meridian Guide, and then give notice to the Clock-observer as he did before. And the Clock-Observer may take notice of the Second, Minute and Hour, and set them down. And then he may see how many Minutes and Seconds the edge and side of the Moon passed by the Meridian later than the Star did, and set them down, and the Hour if it was above an Hour. And the same is to be done, if the Moon cometh to the Meridian before the Star. And if the Pendulum Clock goeth well, the Operation will be good, if the Moon cometh to the Meridian two or three Hours after the Star, or before it. And if the Moon is not come to the Full, then he that observeth it, may give notice when the West-side and edge of the Moon just toucheth the Meridian Guide and is passing out of sight. And if the Moon be near the Star, it may be convenient to cover the body of the Moon with a Board or any thing else, while the Star passeth by the Meridian, that the brightness of the Moon may not too much darken the Star.

And as for the motion of the Moon; when she is in her mean motion toward the East, she moveth so far from a fixed Star, that she cometh to the Meridian, in her diurnal Motion, about 54 Minutes later than a fixed Star in one Revolution round the Earth. The Sun when he is in his mean motion towards the East, cometh

eth to the Meridian, in his diurnal motion, near 4 Minutes later than a fixed Star in 24 Hours. And the Moon in her mean Motion towards the East, cometh to the Meridian above 50 Minutes later than the Sun, and about 54 Minutes later than a fixed Star in one Circuit about the Earth. And if the Moon cometh one Night exactly with a fixed Star, the next night She will be at the Meridian about 54 Minutes later than this fixed Star, according to her middle motion. But sometimes she will come to the Meridian above an Hour later than a fixed Star; and sometimes she will not be 50 Minutes later than a fixed Star in one Revolution round the Earth. If the Moon be in it's greatest Latitude from the Æquator about the Tropick of *Cancer* or of *Capricorn*, and in her *Perigæum*; then she will come to the Meridian above an Hour later than a fixed Star in one Circuit about the Earth. But if the Moon be at the *Æquinox*, and in her *Apogæum*, then she will not be 50 Minutes later. But here we may know exactly how much later than a fixed Star the Moon will come to the Meridian at any time, in one circuit about the Earth, by observing their passing by this Meridian Guide two nights together, and observing what distance of time is between them. For if (for Instance) the Moon be near the Star *Aldebaran*; and if it be observed (according to the Directions given before) that the Moon passed by the Meridian exactly 3 Minutes after this Star upon *Monday*-night; and if it be observed again, that the Moon passeth by the Meridian on *Tuesday*-night exactly an Hour and three Minutes after *Aldebaran*: Then we may see here, without any more trouble, that the Moon cometh to the Meridian a just Hour later than this Star in one Revolution about the Earth; and that the time of the Moon's motion about the Earth at this time is a just Hour longer than the motion of this Star about the Earth. And by this way *Astronomers* may see exactly how fast or how slowly the Moon moveth in her Monthly Course. But there will often be some inequality in the Moon's motion about the Earth in one Circuit, and the Moon will sometimes move a little faster, or a little slower from a fixed Star in the first part of the Circuit than she doth in the last. And when there is cause for it, allowance must be made for the inequality of the Moon's motion in one Circuit about the Earth. And there are three motions of the Moon in her Monthly Course, which make an inequality in her diurnal Motion about the Earth.

First,

First, the Moon moveth a little faster in the Full and Change, than it doth in the Quarters. And the greatest inequality in this motion is in the middle between the Full and the Quarters, or between the Change and the Quarters. And the best place for Observations in respect of this motion, is at the Full, or at the Quarters. But the inequality here in one Revolution about the Earth, will be but small and not much material.

Secondly, the Moon moveth faster in her *Perigæum* than she doth in her *Apogæum*. And the best Place for Observations in this respect is at the *Perigæum*, or at the *Mediums*, or at the *Apogæum*. And the greatest inequality of this motion is between the *Perigæum* and the *Mediums*, or between the *Apogæum* and the *Mediums*. And if observations are made when the Moon is in the Mid-way between the *Perigæum* and the *Mediums*, or between the *Apogæum* and the *Mediums*; then allowance must be made for the inequality of the Moon's motion in this respect, in one Circuit about the Earth, or else there will be a little Error in the Longitude of Places that are taken at this time.

Thirdly, the Moon moveth faster in her greatest Latitudes from the *Equator*, than she doth at the *Equator*. And the best Places for Observations in this respect, are when the Moon is in her greatest Latitude North or South, or at the *Equinoxes*. And the greatest inequality in her motion in this respect, is in the middle between her greatest Latitudes and the *Equator*. And here allowance also must be made for the inequality of her diurnal Motion in one Circuit about the Earth, or else there will be a little Error in the Longitude of Places taken from Observations at this time, if the Places are very remote from us.

And now, as to the Trial and Proof of the Longitude of Places; if it be observed here at *London*, that the Moon passed by the Meridian here, exactly 3 Minutes after *Aldebaran* upon *Monday* night; and if it be observed here again, that she passed by the Meridian here upon *Tuesday*-night exactly an Hour and three Minutes after *Aldebaran*; Then we see that a just Hour of tardation from this Star is to be allowed for this Circuit about the Earth, and that all the Observations that are made in this Circuit of the Moon about the

the Earth, must be allowed their Proportions according to a full Hour for the whole Circuit of the Moon about the Earth. If then it be observed here at *London*, that the Moon passed by the Meridian here exactly 3 Minutes after *Aldebaran* upon *Monday* night; And if it be observed again the same night afterwards at a remote Place Westward, that the Moon passed by the Meridian there exactly 18 Minutes after *Aldebaran*, and 15 Minutes later after this Star then she did at *London*; Then it plainly appeareth that a quarter of the Hour of Tardation is spent and gone; and therefore that the Moon hath now at this Place just finished a quarter of her diurnal Circle, and is now just 90 Degrees from the Meridian of *London*; and that this Place, at whose Meridian the Moon now is, is exactly 90 Degrees in Longitude Westward from *London*. This is clear Demonstration, if the observations be true, and the motion of the Moon in the whole Circuit be allowed to be equal; and no one that understands it, can deny it. Again, if it be observed at another Place, remote from this Westward, that the Moon passed by the Meridian there exactly 33 Minutes after *Aldebaran*, and half an Hour later after this Star then she did at *London*; It then appears that half the Hour of her tardation is spent and gone; and therefore that she hath now at this Place finished just half her Circuit about the Earth, and is now 180 Degrees from the Meridian of *London*, and that this Place is exactly 180 Degrees in Longitude from *London* both Westward and Eastward, and just opposite to us, in respect of its Longitude. And if it be observed again at another Place after this, in the East, that the Moon passed by the Meridian there exactly 48 after *Aldebaran*, and 3 quarters of an hour later after this Star, than she did at *London*; Then it is plain that she hath at this Place finished 3 quarters of her Circuit about the Earth, because 3 quarters of the Hour of her tardation are just finished; and that this Place is exactly 90 Degrees in Longitude Eastward from *London*. And then upon *Tuesday*-night the Moon will come to the Meridian of *London* again, an Hour and 3 Minutes after *Aldebaran*, and shew that these Places are exactly so many Degrees in Longitude distant from *London*, if her motion be allowed to be equal in the whole Circuit. But here will be some inequality: And where there is inequality in the Moon's motion in one Circuit, allowance must be made for it, or else the Longitude will not be exactly shewed. And here we may take notice that the name of the Day and Night must be some where changed. And because the *Europeans* seldom pass over the *Pacific* Sea, therefore they seem

to make the change of the Day there, beyond the Island of *California*, accounting it *Monday*-noon when the Sun is at the Meridian of *California* and *Tuesday*-noon as soon as the Sun cometh to the Meridian of *Japan*. But if a day be mistaken in these Observations, the Error will be so great that it will shew itself. But I return and propose another Example.

If it be observed here at *London*, that the Moon passed by the Meridian here exactly two Hours after the *Scorpion's Heart* upon *Thursday*-night; and if it be observed again upon *Friday*-night that it passed by the Meridian here three Hours after this Star, and an Hour later than it did upon *Thursday*-night; Then it appeareth, that a just Hour is to be allowed for the Moon's Tardation in this Revolution round about the Earth, and that all Observations in this Circuit must have their parts accordingly, if there should be no inequality in the Moon's motion. And if it be observed in this Revolution at another remote Place Westward, that the Moon passed by the Meridian there, just two Hours and 10 Minutes after the *Scorpion's Heart*, and 10 Minutes later after this Star, than she did at *London*; Then it appears that a sixth part of the time of her tardation is spent and gone at this Place, and therefore that she hath now finished a sixth part of her Circuit about the Earth, and that she hath now gone 60 Degrees from the Meridian of *London*, and that this Place is just 60 Degrees in Longitude Westward from *London*. Again, if it be observed, at another Place Westward from this, that the Moon there passed by the Meridian just 2 Hours and 20 Minutes after the *Scorpion's Heart*, and 20 Minutes later after this Star, than she did at *London*; It is then plain that a third part of the Tardation-time is spent and gone; and therefore that the Moon hath here finished a third part of her Circuit about the Earth, and is now 120 Degrees from the Meridian of *London*, and that this Place is 120 Degrees distant from *London* in Longitude Westward. And if it be observed at a Place in the *East* in this Circuit, that the Moon passed by the Meridian there just 2 Hours and 40 Minutes after the *Scorpion's Heart*, and 40 Minutes later than she did at *London*; It is then clear that two third parts of the Hour which was lost in the whole Circuit, were spent and gone at this Place, and therefore that the Moon had then performed two third Parts of this Revolution about the Earth, and that this Place is 120 Degrees in Longitude, distant from *London* Eastward; if her motion be allowed to be equal in the whole Circuit. And as
for

for the exact adjusting of the inequality of the Moon's motion in any Circuit about the Earth, they may make use of *Astronomical Tables*. And Tables may be made for this Purpose to shew exactly how many Seconds of time extraordinary are to be allowed to any Hours or Parts in a Circuit; and how many Seconds are to be deducted from any Hours or Parts in a Circuit. And the Meridian Guide will shew exactly how many Minutes and Seconds above, or under an Hour are to be allowed to the whole Circuit of the Moon about the Earth. And according to these Examples all Accounts may be cast up, that are made by observations any where in the World. And when observations are made, it may be convenient to make them 3 or 4 Nights together, if the Air be clear, for the greater certainty. And this Way and Method of finding the Longitude of Places by observing the motion of the Moon by a fixed Star, I propose and recommend as the best and most exact Way and Method of knowing the Longitude of all Places in the World, where observations may be made. And if the Meridian Guides and the Sights thereof be exactly fixed to observe the true Meridians of the Places, and a due allowance be made for the inequality of the Moon's motion, and if the Clocks keep a due time, I do not doubt but that the distances of Places in Longitude may be as exactly known as can well be desired. And if Observations be made here at *London*, and at *Falmouth* or the *Lizard Point*, you may soon see a Trial and Proof of this Way and Method of finding the Longitude of Places, and of the exactness of it, if the Meridian Guides and the Sights be exactly placed and fixed, but if the Meridian Guides and Sights be awry, and a false Meridian be observed, then the Work will be lame and imperfect. And the Planets *Mars* and *Jupiter* will serve as well as fixed Stars, and are rather better than fixed Stars for this use, when they are opposite to the Sun, by reason of their Retrogradation.

This Way is far more exact than the partial Eclipses of the Moon, and more exact even than the total Eclipses of the Moon. For here the Artists and Observers may take what times they please, as soon as the Moon is removed far enough from the Sun; and they may make their Observations when the Moon is in it's greatest Latitude from the *Aequator*, and in it's *Perigaeum*, when the *Eastern* motion of the Moon will be the greatest and swiftest; and when her diurnal motion will be the slowest, and her tardation the greatest;

and when she will move the greatest space towards or from a fixed Star in one Circuit about the Earth, and there will be the greatest distance between the Place where she is one night, and the Place where she will be the next night; And therefore the greatest distance between the Place where the Moon is when it is observed at *London*, and the Place where the Moon will be when it is observed in another Place afterwards in that Revolution about the Earth. And again, in the total Eclipses of the Moon, the Moon's motion cannot be so curiously and exactly observed as it may be this way: Because the two sides and edges of the Moon (which are the two curious Points to be observed) will be darkned, and again enlightened leisurely and by Degrees, and there will be a quarter of an Hour between the first Obscuration and the total darkning of the last edge of the Moon as it entereth into the Shadow of the Earth; and the same time again from the first illumination of the first edge of the Moon, when it cometh out of the Shadow of the Earth, till it be fully and perfectly enlightened. And a man in one part of the Earth may, in this respect, make his Observation of an Eclipse several Minutes sooner or later than another Man doth in another Place of the Earth. And this makes total Eclipses much more uncertain than my Way for finding and knowing the certain Longitude of remote Places: For in my Way and according to my Directions, the motion of the edge of the Moon, and of a Star, by the Meridian, may be observed to a Second or two of time, and there need be no Error in the Observation. And again, heretofore the true time of the night, when Observations have been made, hath not been so carefully regarded, but the time hath been taken by an uncertain and ordinary Dial and Watch. But according to my Directions, the Meridian and time may be as perfectly and exactly known as the art of Man is able to make it. And if due care be taken, there will be no material Error in this respect. In these respects all Ingenious Artists may see, that my Way and Method for knowing the Longitude of Places, is far more exact than the total Eclipses of the Moon, which are the best Way that hath been hitherto used; And that my Way and Method is to be preferred before them, both for exactness, and also for the multitude of Trials and Proofs that may be made by it, for one that can be made by total Eclipses of the Moon.

Here

Here you may see that the Clock is relied upon, only to shew the exact time that intercedes between the Moon's passing by the Meridian-Line, and a fixed Star's passing by it; which some times may be but a quarter of an Hour, and will seldom be above 2 or 3 hours. But if the Pendulum-Clock be good and keepeth a very steady and true time, this Work may be performed by the Sun and Moon and a Pendulum Clock, without the use of a fixed Star. And then the Clock must be set exactly by the Sun when it passeth by the Meridian: And the Observer may take notice when the last edge of the Sun is just covered with the Meridian Guide, and then set the Clock just one Minute past 12; because the Center of the Sun will then be one Minute past 12. And then he may observe again the next day, how much it differs from the Sun; and again the third day: And make allowance for the difference, if it be material and much. And if it be *Monday*, and the Moon at a convenient distance from the Sun, and in her greatest Latitude from the Equinoctial Line, and in her *Perigæum*, when they are together, (which will be the best) they may observe on *Monday*-night (according to the directions given) at what Hour, Minute and Second the Moon passeth by the Meridian, and observe again on *Tuesday* night, at what Hour, Minute and Second she passeth by the Meridian again. And if it be observed here at *London*, that the Moon passed by the Meridian here exactly at 11 a-Clock upon *Monday*-night; and if it be observed again upon *Tuesday*-night, that she passeth by the Meridian at *London* exactly 56 Minutes after eleven a-Clock; Then we may see that just 56 Minutes are to be allowed for her tardation in this whole Circuit about the Earth; and that all Observations that are made this Way, by her tardation from the Sun, in this Circuit, must be cast up according to 56 Minutes of tardation in the whole Circuit. And, for example, if it be observed here at *London*, that the Moon passed by the Meridian here exactly at Eleven a-Clock upon *Monday* night; and if it be observed at a place remote towards the West, that she passed by the Meridian there exactly 7 Minutes past eleven a-Clock; Then it is clear that an eighth part of the time of her tardation is now gone, and an eighth part of the 56 Minutes is lost and spent, which are allowed for the whole Circuit; And therefore that the Moon hath compleated an eighth part of her Circuit from *London* at this Place, (allowing her motion to be equal) And that this

Place

Place is just 45 Degrees in Longitude distant from *London* towards the *West*. And if it be observed again at another Place farther Westward, that the Moon passed by the Meridian there just 21 Minutes past Eleven a Clock; Then it is manifest that 3 eighth Parts of the Time of her tardation, and of the 56 Minutes are lost and gone; and therefore that the Moon hath now at this Place finished three eighth parts of her Circuit about the Earth; and that this Place is 135 Degrees in Longitude Westward from *London*. And if it be observed again afterwards at another Place farther and remote from this, that the Moon there passed by the Meridian just 35 Minutes past Eleven a Clock; Then it is manifest that 5 eighth parts of the time of her tardation and of the 56 Minutes were then spent and gone; and therefore that the Moon had then finished five eighth parts of her Circuit about the Earth; and that this Place is 125 Degrees in Longitude Eastward from *London*. And if it be observed again at another Place afterward in this Circuit, that the Moon passed by the Meridian there, 49 Minutes past Eleven a Clock; It is then plain that seven eighth Parts of the time of her tardation and of the 56 Minutes were now spent and lost at this Place; and therefore that she had now finished seven eighth Parts of her Circuit about the Earth, and that this Place is 45 Degrees in Longitude distant from *London* towards the *East*. This is plain demonstration, if the observations are exactly made, and the motion of the Moon be equal through the whole Circuit. And if there be a little inequality in the motion of the Moon in one Circuit about the Earth when Observations are made; then a little allowance must be made for it.

This Way is not so exact as the former by the use of a fixed Star or a Planet; but yet, if the Pendulum Clock keepeth a true motion with the Sun, it will do very well, and is more exact than the total Eclipses of the Moon, and is a very ready and easie Way. And if Observers in Foreign Parts do but make Observations according to these Directions, and set them down, and send them to the Cities in *Europe* to which they belong; then they may be compared with the Observations made there at the same time, and the Longitude of Places will be certainly known, if the Observations be true and exact. And if the Places be as far as *Japan* and *Solomon's Islands*, the Longitude may be known to less than half a Degree. And as often as any Ships go from any Places in *Europe* to any other Places

Places in the World, Observations may be made while the Ships stay there, and set down in a Line or two, after this manner, *viz.* Observations made by the Moon and the Star *Aldebaran*, at *Bantam* in the *East-Indies*. The Moon passed by the Meridian here *January* the first, 3 Minutes and 15 Seconds after *Aldebaran*. *January* the 2d, 1 Hour, 4 Minutes and 10 Seconds after *Aldebaran*. *January* the 3d, 2 Hours, 5 Minutes and 5 Seconds after *Aldebaran*; and so forward. And as soon as the Ships return home with their Observations, and they are compared with those that were made at the same time at home, the Longitude of the Places will be exactly known, if the Observations are true and exactly made. And by this means the Longitude of all Places may be exactly known in a few Years, where observations may be made. And it will be very needful that Observations should be carefully made at the great Meridian of the Earth, that all the Cities of *Europe*, and all Places in the World where Observations are made, may be set at their due distances from it in all Globes and Maps. And if Observations can be made at *Cape Verde*, that seemeth to me to be the best Place for the Grand Meridian of the Earth; because it is the most Western Part of the Continent, and near the *Equinoctial-Line*. And all the Nations in *Europe* may make known to one another the Longitude of Places where they have made Observations or caused them to be made. And as soon as these Accounts of the Longitude of Places are Published, all Persons that make Globes and Maps, may correct their Globes and Maps by them.

Observations enow, as I suppose, may be made by a Meridian-Guide, for knowing exactly the Longitude of all Places. But if more Observations should be needful, Observations may be made at the Six-a-Clock Hour in the Morning, and again at the Six-a-Clock Hour in the Evening. And this Way of making Observations may be of very great use to the Curious *Astronomers*, for observing the *Parallaxes* of the Sun, Moon and Planets, and for knowing their distances from the Earth more exactly. And this may be done by setting up two great Cocks or Styles, like the Cock of an Horizontal-Dial, about 20 Yards a sunder, exactly *East* and *West* from one another. And first a Piece of Timber 4. or 5 Yards long, with a strait and even face, and a strait line drawn upon it from end to end, may be placed exactly *East* and

and *West*, and levelled with a Water level, 4 or 5 Yards long, for a Basis of one of these Styles. And then a strait Piece of Timber about 8 Yards long, and about a Foot broad and 9 Inches thick, and of an equal breadth all along, may be set up for the Style. The Foot of the Style must be placed exactly at the Line of the Basis, and it must be elevated with the Pole of the Place, and be supported with Feet and Laces, that it may not move or warp and bend, one side being placed toward the *East* and the other towards the *West*. And then the other Style may be so made, and placed exactly *East* or *West* from it, and of an equal height with it, that the line of one of the Bases may agree exactly with the line of the other; which may be tried with a Silk-Line drawn from the farthest end of the one to the farthest end of the other. And behind one of these Styles an hole may be made in the Ground, and a Sight may be there placed, and then it may serve for a Meridian-Guide, to shew when the Moon or a Star passeth by the Meridian. And Sights must be placed to the Styles, to observe when the Edges of the Moon or a Star passeth behind them. The Sights may be made with a notch 6 Inches long, and half a quarter of an Inch wide, and then a Man may make use of both his Eyes: And the Sights may be placed some times upon, and some times under the Styles, as there shall be occasion to make Observation either above or under the Styles, especially in the rising of the Sun, Moon or a Star. And if it may be more conveniently done, one great Style may be made, and two little Styles 2 or 3 Foot long a-piece, and be placed at 20 Yards distance from the great Style, one towards the *East*, and the other towards the *West*, agreeing exactly with the great Style. And then Observations may be made at what Hour, Minute and Second the Moon passeth by the 6-a-Clock-Lines in the Morning and in the Evening; And at what Hour, Minute and Second a Star passeth by these Lines; And how many Hours, Minutes and Seconds are between the passing by of the one and the passing by of the other. And here three Observations may be made in a Day, when the Moon and Star are in the *Northern* Latitude, and the Moon near the Full. And those that are curious may make use of all these three Ways of Observations. And by these Ways they may exactly see and know the true distances of the fixed Stars from one another; and may see at any time exactly how many Degrees, Minutes, and almost Seconds of a Circle are between the Planets, by observing

serving their passing by the Meridian and by the 6-a-Clock-Lines, and observing by the Pendulum-Clock how many Hours, Minutes and Seconds of time are between the passing by of the one and of the other.

And by these Styles the Ingenious *Astronomers* may see how much one Day is longer than another; And they may try to find out the *Parallaxes* of the Sun, Moon and Planets more exactly, with the help of a good Pendulum-Clock; that their distances from the Earth, and their Magnitudes may be better known. And this seems to me to be the exactest way of all to know their true distances and Magnitudes, if great care be used to set these Styles true and exact. For by this way they may find, as exactly as can well be done, what the quantity of the Earth's Diameter is, in respect of the distances of the Sun, Moon and Planets. And first, they may observe what difference in time there is, between a fixed Star's moving from the Six-a-Clock-Line in the *East*, to the Six-a-Clock-Line in the *West*, and again from the *West-Line*, to the *East-Line*. And they may try 2 Stars, one about the Tropick of *Cancer*, and another near the *Equator*. And then they may see what difference in time there is, between the Planet *Mars* his moving from the *East-Line* to the *West-Line*, and again from the *West-Line* to the *East-Line*. But the best way is to observe what difference in time there is, between *Mars* and a fixed Star, as they rise by the 6-a-Clock-Line in the *East*, and as they go down by the 6-a-Clock-Line in the *West*, and as they rise in the *East* again. And by the difference between *Mars* and a fixed Star in rising and going down and rising again, they may see as exactly as can be expected, what the quantity of the Earth's Diameter is in respect of *Mars* his distance from the Earth, when *Mars* is at or near his opposition to the Sun. And as soon as *Mars* cometh to his next opposition to the Sun, this may be tried. And if the Styles be exactly set and elevated, and the Pendulum-Clock goeth true, and several Trials be made, the distance of *Mars* from the Earth will be more certainly known this way, I think, than any other way. But here at *London* we have only the Diameter of the *London* Circle of the Earth to work by, which is not quite two Thirds of the full Diameter of the Earth. But under the *Equator* they have the full Diameter of the Earth to work by, but will there be hinder'd by the light of the Sun, except some means be

used to keep it away. But *Jupiter* may be seen before the Sun is set, and I suppose that *Mars* may be seen also at that time with the help of a Prospective Glass. And then Trial may be made by a good Pendulum-Clock, how many Seconds he is under the Horizon longer than he is above the Horizon; And the Refraction at the Horizon may be known by trying of *Jupiter* the same way under the *Aequator*, when *Jupiter* is opposite to the Sun. For the Earth's Diameter in respect of *Jupiter*, I suppose, is not one Second in time. And if they cannot make Trial at the Horizon, they may make Trial when they are half a Degree above the Horizon. And if the distance of *Mars* from the Earth can be found this way; then the distances of the Sun and of the other Planets may be known by their Retrogradations; And their Magnitudes will be better known. And by observing by these Styles and a Pendulum Clock, the distance between the Moon and a fixed Star as they rise, and as they go down for two or three nights together, they may very exactly know the quantity of the Diameter of the Circle of the Earth where they are, and the quantity of the Diameter of the Earth in respect of the Moon's distance; and hereby know her true distance and magnitude more exactly, as I suppose. And perhaps these Observations of the Moon may be an help to know the distance between her *Apogaeum* and *Perigaeum* more exactly. And by these Styles and Meridian-Guide they may more curiously observe the Moon's motion, and see more exactly what inequality there is in her motion, that a due allowance may be made for it. And if the distance of the Sun can be known this way; then we may know the Diameter of the *Magnus Orbis*; that is, of the Circle of the Earth's Annual motion about the Sun, and try what can be found of the distances of the fixed Stars, and take a better view of them. For there is no doubt to me but that they are all great and glorious Suns, and some of them as great or greater than this Sun which we enjoy; And that they give Light and Heat to Myriads of Earthy and material Globes like this Earth which we inhabit; And that in them the Great and Glorious GOD hath Millions of Corporeal and Intelligent Creatures to worship and adore Him. And without all question some of the fixed Stars are far nearer to us than others are; and for ought we know, some of them may be ten times farther from us than the nearest of them are. By knowing more exactly the distances and magnitudes of the Sun, Moon and Stars we may take a greater Prospect of the glorious
and

and stupendious Works of Almighty God ; which he hath made visible to us ; and be filled with the greater Admiration of them, and of the unconceivable Majesty of that Great and Glorious God that created and governs them all. This way of using Styles and Pendulum-Clocks for the finding out of the distances and magnitudes of the Sun, Moon and Stars seems to me to be more curious and exact than the ways that have been formerly used, so far as I understand them.

By all these ways the Longitude of Places may be exactly known upon the Earth, where Observations are made, if great care be taken. And as often as Ships go from any Places in *Europe*, to other Places in any of the Four Parts of the World, those that go in the Ships may make Observations while the Ships stay there, and bring them back with them. And if they cannot make their Observation so exactly as I have directed ; they may make them as exactly as they can. And if they have not Pendulum-Clocks, they may make use of Pocket-Watches that point at Hours and Minutes ; and they may guess at the Seconds as well as they can. And they may use the Ship-Watches mention'd below. And if all the *European* Merchants will take care to forward this Work, the Longitude of all considerable Places in the World will be exactly known in a short time. And when all considerable Places are exactly known upon the Land of what Longitude they are ; then the Longitude of Places upon the Sea may be better known, when Mariners have such certain Guides by knowing the certain Longitude of Places upon the Land. And for knowing the Longitude of all Places upon Ship-board more certainly, large Ship-Watches of 8 or 9 Inches square may be made to point at Hours, Minutes and Seconds. And for this Purpose, I have invented and contrived Ship-Watches to go after a new Way, which I hope will keep time more exactly than Pocket-Watches, and do great Service upon Ship-board for knowing more certainly the Longitude of Places. And when these are well made by the Ingenious Clock-makers and Watch-makers in *London*, to point at Hours, Minutes and Seconds, they will shew more exactly the Hours, and Minutes, and Seconds, than Hour-Glasses and Minute-Glasses of Sand. And by this means and the help of these Ship-Watches all Governours of Ships may see more perfectly how fast the Ship saileth, and how far they sail in an Hour. And this will be one way whereby the Longitude of Places will be better known

upon the Sea. And for more certainty that it may be clearly known how much a League is, it will be convenient that the *English*-men should always compute and reckon their Leagues at 20 to a Degree in Latitude, and in Longitude under the Equinoctial Line; but in the *Temperate Zones* a Degree in Longitude will be a great deal less than 20 Leagues. This may be very necessary for any Directions or Rules that shall be made for Navigation, to know exactly how much a League is.

But if these Ship-Watches, when they are well made, will answer my hopes and expectations, and will keep time almost as exactly as a Pendulum-Clock; Then one of them may be set exactly with the true Hour and Minute of the Day when a Ship goeth forth from any Place; And afterward upon the Sea, by seeing how much the Ship-Watch is too fast or too slow for the true Hour and Minute of the Day where the Ship is, they may see how many Degrees in Longitude, either Eastward or Westward, they are from the Place from which they came. As for Example, If a Ship setteth out from *Plymouth* directly towards the *West*, and the Watch is set exactly with the Sun at *Plymouth*; And if after the Ship hath sailed sometime Westward, they carefully observe what time of the day it is there upon the Sea, and find the Ship-Watch to be 16 Minutes too fast: Then it appeareth that the Ship hath gone four Degrees in Longitude Westward from *Plymouth*. And if they sail on still Westward, and after some distance observe the true time of the day again, and find that the Watch is just half an Hour too fast; then the Watch sheweth that they have gone seven Degrees and an half in Longitude Westward from *Plymouth*. And if after a time again, when they have sailed farther, they observe the Hour of the Day again, and find that the Watch is a just Hour too fast; Then the Watch sheweth that they have sailed 15 Degrees in Longitude Westward from *Plymouth*. And 4 Minutes too fast are to be allowed for every Degree in Longitude Westward. And when the Longitude of the *Cape of good Hope* is certainly known; then those that sail by it, may set the Ship Watch with the Sun there. And if the Watch be set with the Sun there, and they sail forward sometime towards the East, and observe what a Clock it is by the Sun there, and find that the Watch is 20 Minutes too late for the Sun there; Then it appeareth that they are 5 Degrees in Longitude Eastward from the *Cape of Good Hope*. And if they sail still forward towards the

the *East*, and after a time again make trial and find that the Watch is an Hour and 8 Minutes too late for the Sun there; then it appeareth that they are 17 Degrees in Longitude Eastward from the *Cape of good Hope*; and so forward, allowing 4 Minutes in lateness for every Degree in Longitude Eastward. But here you must not expect that certainty, that is in the former ways and directions of finding the Longitude of Places upon the Land; (for they are plain Mathematical Demonstration) But yet if these directions following be carefully observed and practised, I hope this Ship-Watch may be very useful and do very great service upon Ship-board, for knowing the Longitude of Places. First, this Ship-Watch must be set exactly with the Sun, or rather with the mean Motion of the Sun, at the going out from a Place. Secondly, regard must be had to the Anomaly of the Sun, and to the Equation of time. Thirdly, the Watch must be carefully observed how much it goeth too fast or too slow for the mean Motion of the Sun, and allowance must be made for it. Fourthly, the true time of the day upon the Sea must be observed and known as exactly as can be. Fifthly, it will be convenient to regulate this Ship-Watch as often as they come to any Place whose Longitude is certainly known.

And as for the first of these directions, it will be convenient that a Pendulum Clock be kept at some convenient Place by the River below the Bridge, for the Port of *London*, with a great Bell that may be heard at a great Distance, and with two large Indexes that may be seen at a great distance, one pointing at the Hours, and the other at the Minutes. And then the Officers in all Ships may hear the Clock, or else observe the Indexes as they pass by, and see what Hour and Minute it is, and set the Ship-Watch by them, guessing at the Seconds as well as they can. And for the exact keeping of this Clock with the Sun, or rather with the mean Motion of the Sun, an *East* or *West* Dial may be made by a Skilful Artificer, about a Yard long, with a Cock like an Arch, half a Yard high from the Plain, and with a little hole in the top, to let the *Radius* of the Sun thro' perpendicularly upon the 6-a-Clock-Line; and containing the Hours only from 4 to 9, or from 3 to 8. And when this Dial is fixed either to the *East* or *West*-side of the House, and carefully examined by a large Quadrant and the Clock, both in the rising and going down of the Sun, that it be set true; then the Clock may be carefully kept by it. And other Places may cause a Clock to be kept in the same manner: Se.

Secondly, as for the Equation of time, several Almanacks and other Books have Tables of Equation. And a Table of the Equation of time may be put in a little Book for the Mariner's Guide.

Thirdly, as for the motion of this Ship Watch, they may observe it for some days before they set out, and when they come into any Harbour again. And if it goes much too fast or too slow, they may alter the motion when they are in an Harbour and lie at Anchor. But in a Voyage upon the Sea it will not be convenient to alter the motion, nor the Indexes, except it be at a Place whose Longitude is certainly known. And after this Watch is set exactly with the Pendulum-Clock by the River, as they go forth; they may examine it again, when they come into the *British*-Channel under the same Meridian again, by observing the true Hour of the Day then, and making allowance for the Equation of time: And then they will see whether it goeth true or not; and if not, how much too fast or too slow. And when the Longitude of the *Lizard*-Point is certainly known; they may then again examine it's motion by observing the true Hour of the day there, and see how it goeth. And if the *Lizard*-Point be found to be just Six Degrees in Longitude from the Pendulum-Clock by the River; Then the Ship-Watch should be 24 Minutes too fast, if it goeth true, and no allowance be to be made for the inequality of time. And care must be taken that this Watch be duly wound up; for the use of it is lost for the present, if that be neglected.

Fourthly, as for the true Hour of the Day upon the Sea, the best way to know it, is by the rising and setting of the Sun: For then the Horizon will shew it without the use of an Instrument, and more exactly, if the Air be clear. And the difference between the rational and sensible Horizon is a meer trifle in this respect, there being, as I suppose, not above 2 Seconds of time in the Sun's rising, and 2 Seconds in the Sun's setting, between them. But the Refraction of the Sun is very considerable and to be regarded: for the Sun will appear above the Horizon, when the Center of the Sun is really exactly level with the Horizon. And when the Center of the Sun is really (for we must here make a distinction between Really and Apparently; when the Center of the Sun is really) level with the Horizon.

Horizon may be this Way known upon the Sea. They may observe, when they are under the Equator, when the lower side of the Sun is apparently level with the Horizon as it riseth, and when the lower side of the Sun is level with the Horizon again as it goeth down: And then by this Ship-Watch they may see if there be exactly 12 Hours from the rising of the lower side of the Sun to the setting of the lower side of the Sun; and also just 12 Hours from the setting of the lower side of the Sun to the rising of the lower side. And if there be just 12 Hours above and just 12 Hours below this rising and this setting; then this may be always accounted the true rising and setting of the Sun upon the Sea, when the lower side of the Sun is level with the Horizon both in rising and setting: For then the Center of the Sun is really level with the Horizon in the Morning and in the Evening, which is the true rising and setting of the Sun. But if Mr. Street's Rules of Refraction be true, and the Refraction at the Horizon be half a Degree, then the lower side of the Sun will appear about half the Diameter of the Sun above the Horizon, when it's Center is really level with the Horizon. And if they find the day from the rising of the lower side to the setting of the lower side of the Sun to be 2 Minutes longer than the night, under the Equinoctial-Line: Then they may always account this the true rising and setting of the Sun, when the lower side of the Sun is half it's Diameter above the Horizon. By this means they may know the true rising and setting of the Sun upon the Sea, and also of the Moon and Stars. And under the Equinoctial-Line it will be 6 a Clock in the Morning, and 6 a-Clock in the Evening, when the Center of the Sun is really level with the Horizon: And by this Way with the help of this Watch, they may know when the Center of the Sun is really level with the Horizon; and when it is 6 a-Clock in the Morning and in the Evening under the Equator. But the Refraction will be greater when the Air is gross and misty, than when it is clear. And if Tables be made of the Sun's rising and setting for several Latitudes, in a Book to be the Mariner's Guide; Then they may know by these Tables the time of the Sun's rising and setting in several Latitudes. And when they cannot know the Hour of the Day by the rising and setting of the Sun, which is the best way; then they must use their Quadrants for the finding of the true Hour of the Day upon the Sea. And the Ship-Watch if it goeth well and is well observed, will shew them in what Degree of Longitude they are from the Place which they came from. And if they sail towards the *West* or *East* presently

presently after the Watch hath been true set, I hope this Ship-Watch will give great assistance and be very useful in shewing the Degrees of Longitude upon Ship-board. And trial may be made of these Watches in passing from *England* to *New-found land* in *America*: And also in passing from the *Cape of Good Hope* towards the *East*. But if a Ship be long upon the Sea after the Watch hath been set; it must not then be expected that the Watch should shew the Longitude of Places so exactly as it will in a shorter time.

Fifthly, for the often regulating of these Ship-Watches, it will be necessary that the Longitude of the *Cape of Good Hope*, and of all other remarkable Places in the World should be exactly known, by trying and examining them by the Rules given before for finding of the true and exact Longitude of Places upon the Land. And it is necessary that this should be done as soon as it can conveniently be done.

I have shewed before how the Refraction of the Sun at the Horizon may be known upon the Sea; That is, how they may know how high the Body of the Sun will appear, when the Center of the Sun is really exactly level with the Horizon: And it may be convenient to make trial of this upon the Land. And because the motion of the Sun is quick at the Equinoxes, and the Sun altereth it's Course in one day, and the Work may be interrupted by Clouds, it will be more convenient to make trial of the Refraction of the Sun at one of the Tropicks, when the Sun varieth very little for a Week together, and not much for a Fortnight. And this may be done by fixing a strait Beard to two Stakes about 4 Foot high for an Horizontal-Guide, with the edge upward, and one side towards the rising Sun, and levell'd with a Water-Level 4 or 5 Yards long. And then a Sight may be fixed to a Stake at 20 Yards distance, to observe the rising Sun, and made level with the Horizontal-Guide by levelling of them both ways; both from the Sight and from the Horizontal-Guide: for a double levelling is the most exact. And then the Artist may see whether he hath a perfect and level Horizon or not. And if he hath not a perfect and level Horizon, but the Earth appeareth above the Horizontal-Guide; then he may sink the Sight half a Degree below the Horizontal-Guide. And in the like manner another Horizontal-Guide and Sight must be fixed up, to observe the setting Sun. And then the Artist may see by a Globe

or any other way (for there is a more exact way than a Globe) at what Hour, Minute and Second, if he can, the Center of the Sun will be level with the Horizon, when the Sun riseth; and at what Hour, Minute and Second, as near as he can, the Center of the Sun will be level with the Horizon as the Sun goeth down. And then he will see how many Hours, Minutes and almost Seconds there are, between the true rising and setting of the Sun. And by the help of a good Pendulum Clock and these Horizontal-Guides, he may see how high the Sun will appear when the Center of the Sun is really level with the Horizon. First, he may set the Clock with the true and real rising of the Sun, when the lower side of the Sun appeareth to be level with a perfect Horizon, and the upper side of the Sun is half a Degree high; and then see how many Minutes too much there will be between that time and the setting of the lower side of the Sun, and when the upper side of the Sun as it goeth down is just half a Degree above a level. And after he may make trial when the Center of the Sun appeareth to be half a Degree above the Horizon in rising and setting. And by several Trials he will find how high the Sun will appear to be when the Center of the Sun is really level with the Horizon, and see how much the Refraction of the Sun is at the Horizon. And this may be a Guide to Mariners upon the Sea that know it not. And these Horizontal-Guides seem to me to be the best means for fixing the Sight exactly to the Meridian-Guides, where they can be conveniently used, and more exact than a large Quadrant, where great curiosity is to be used. And thus have I shewed how the true Hour of the day may be known both upon Ship board, and also upon Land; and that the best way to know this, especially upon the Sea, is to know the true time of the Sun's rising and setting, and how much is to be allowed for the Refraction of the Sun at the Horizon.

It will also be convenient that the Amplitude of the Sun's rising and setting; that is, his distance from the *East* and *West* towards the *North* or *South*, when he riseth and setteth, be set down with the Tables of the Sun's rising and setting. This will exactly shew the variation of the Compass or Needle, and be a great help to young Governours and Navigators of Ships. And if all the experienced Ship-Masters and Mariners in *Europe*, that have made any curious and useful Observations, would (like the Blessed Children of Love) communicate and make known their useful Observations; they might

also be put in a Book for the Mariner's Guide. And the dangerous Rocks, and Sands, and *Vorago's* or Whirl-Pools, and all other Places of Danger, that have been observed, might be set down in what Latitude and Longitude they are, that they might be avoided. Upon the Coast of *Norway*, they say, that there is a *Vorago* or swallowing Pit, that will swallow down Vessels that sail over it heavy loaded; and after a time throw them up again. And if this be so, this seems to me to be the cause of it, *viz.* That there is a subterraneous Passage for the Water thorough Rocks into the *Baltick-Sea*. And that when the Tide riseth at the swallowing Pit, and the superficies of the Sea is higher there than in the *Baltick-Sea*, then the Water runneth through this subterraneous Passage into the *Baltick-Sea*. And that afterwards when the Tide is retired back again, and the Water in the *Baltick Sea* is higher than it is at this *Vorago*; the Water then returneth back again through this Passage, into the Sea or Ocean again, and then throweth out the Vessels that were lodged in the Mouth of it. And this, and all such Places of Danger, and all other useful Observations may be collected together and put down in a Book, if all experienced Seamen in *Europe* are willing to lend their helping hand to this Work. And then most of these things may be noted in Terrestrial Globes and Maps, that a Man may readily observe them. The dangerous Rocks and Sands may be noted with such Marks as the Map-makers use for them: and a *Vorago* may be noted with a little Circle, and [a *Vorago*] be writ by it. In some Places the Water of the Sea moveth constantly one way. And this may be shewed upon a Map by a Mark like a little Arrow or Dart with a full line: And the point of the Dart will shew which way the Water moveth constantly in that Place. In some Straits the Water moveth some times one way, and some times the other. And this may be noted with two little Darts, one made without the Strait pointing at the Strait; and another made within the Strait or on the other side of the Strait, pointing also at the Strait. And these will shew that the Water hath a double motion in that Strait. In some Places the Wind bloweth constantly one way, especially in the *Torrid-Zone*. And this may be noted upon a Map with a little Arrow made with Pricks or Points only, to distinguish it from the Water-Mark with a full line. These, and such useful Observations as these, may be noted upon Globes and Maps: And then by casting an Eye upon a Globe or Map, a Man may readily observe them. And they will not only be ser-

viceable to Young Seamen, but give some satisfaction also to those that are desirous to know these and such remarkable things of the Works of Almighty God. And thus have I given you what Assistance I well can, as to the great Work of Navigation, with some little advice concerning *Astronomy*: And I have shewed you how the Longitude of all Places upon Land may be certainly, easily and speedily known to half a Degree and less, altho some of them, should be Ten thousand Miles from *London*, and in the farthest Parts of the Earth, if care be taken and my Directions be duely observed. And I have also shewed you how the Longitude of Places may be better known upon the Sea by the help of this Ship Watch, when it is brought to Perfection by the Ingenious Clock-makers and Watch-makers; and when Mariners have had experience of it and know how to use it, and my Directions are duely minded.

I have here willingly and readily employed my Talent for your Good and Benefit, and have endeavoured to satisfy your desires as far as I well can; and I hope my Advice may be of very great Advantage to you. And now I desire that you would not be ungrateful to me, but that you would be ready to help me, and employ your Talents for the Good of Poor and Nedy Christians that want your Help and Charity. I do not crave those great Sums of Money, which (they say) some of you have proffer'd to him that should perform this Work, but shall be contented with a far less Reward, and will take what you are willing to give me. I hope I have here performed this great Work to the satisfaction of all Ingenuous Men, that understand it, and also to your great Benefit and Profit: And therefore I hope that I may reasonably request of you, that you would pity and help me in this poor and low Condition that I am now in: For I have been deprived of my Benefice and Place of Profit above Sixteen Years, and am left to be supported by the Charity of kind and well-disposed Christians. And, alas! true Christian Love and Charity is very cold: For I have been in *London* above Five Years, and have not received any help and kindness from any Persons in *London*, except my own Relations, and one Gentle Woman who sent me a Crown. One Noble and Worthy Person sent me Five Guineas out of the Country, and some others sent me some small Tokens of their Kindness to me: And they came seasonably to me to relieve me in my great Necessity, or else I had been

been at a very great Strait. And I wish that their Kindness to me may be their Comfort and Joy in this World; and that it may tend to their Eternal Joy and Happiness in the World to come. And I would have you all to employ your great Talents of Wealth and Riches to the Glory of Almighty GOD, and to the Relieving all poor and necessitous Christians, that want your Help and Assistance, especially of all good and pious Christians that suffer for a just and righteous Cause. This will be your Joy and Comfort here, and tend much to your Eternal Glory and Happiness in the World to come. This will be the best way to procure the Blessing of Almighty God upon Yourself, your Families, and your Goods: And if you are kind and merciful to your poor Brethren; then you may cheerfully hope to find Mercy in the Days of Darkness, and in the Dreadful Judgments of GOD that are coming upon us. Read over the Five and Twentieth Chapter of St. Matthew's Gospel, and do good to all the poor and distressed Members of the Blessed JESUS, that when he shall judge the World in Righteousness, that joyful Sentence may be pronounced upon you; *Matth xxv. 34. Come ye Blessed of my Father, inherit the Kingdom prepared for you from the Foundation of the World: For I was hungry, and ye gave me meat* ———. Here you may see beforehand how Matters will go at this Great and Dreadful Day: And therefore be Wise betimes, and make a due Preparation for it, for your Eternal Happiness and Well-Being in the World to come.



From your Servant

Digby Bull.

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